73rd MORSS CD Cover Page

712CD

For office use only 41205

UNCLASSIFIED DISCLOSURE FORM CD Presentation

21-23 June 2005, at US Military Academy, West Point, NY

Please complete this form 712CD as your cover page to your electronic briefing submission to the MORSS CD. Do not fax to the MORS office.

Author Request **(To be completed by applicant) - The following author(s) request authority to disclose the following presentation in the MORSS Final Report, for inclusion on the MORSS CD and/or posting on the MORS web site.**

Name of Principal Author and all other author(s): Jeffrey R. Cares

Principal Author's Organization and address:
Alidade Incorporated
31 Bridge Street
Newport, RI 02840

Phone:_401-367-0040_____

Fax:___401-633-6420_____

Email:__jeff.cares@alidade.net_____

Original title on 712 A/B: **New Metric and MOEs for Unmanned, Distributed Forces**

Revised title:

Presented in (input and Bold one): (**WG24,** CG___, Special Session ___, Poster, Demo, or Tutorial):

This presentation is believed to be:
UNCLASSIFIED AND APPROVED FOR PUBLIC RELEASE

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
22 JUN 2005	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
New Metrics and MOEs for Unmanned, Distributed Forces	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Alidade Incorporated 31 Bridge Street Newport, RI 02840**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM201946, Military Operations Research Society Symposium (73rd) Held in West Point, NY on 21-23 June 2005. , The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**UU**	**27**	

ALIDADE
INCORPORATED

New Metrics and MOEs for Unmanned, Distributed Forces

Jeffrey R. Cares

73rd MORSS

Introduction

- Existing models focus on attrition and can not adequately represent proposed Information Age combat processes.
- Three views of a Distributed Networked System:
  - Structure
    - What are the links, nodes, boundaries and rules for connection?
  - Dynamics
    - Do actual or potential networked effects exist?
  - Evolution
    - What trajectories do the descriptive characteristics take?
      - Do they converge, diverge or cycle?
- These three perspectives are used to create the Information Age Combat Model

ALIDADE
INCORPORATED

New Metrics
and MOEs

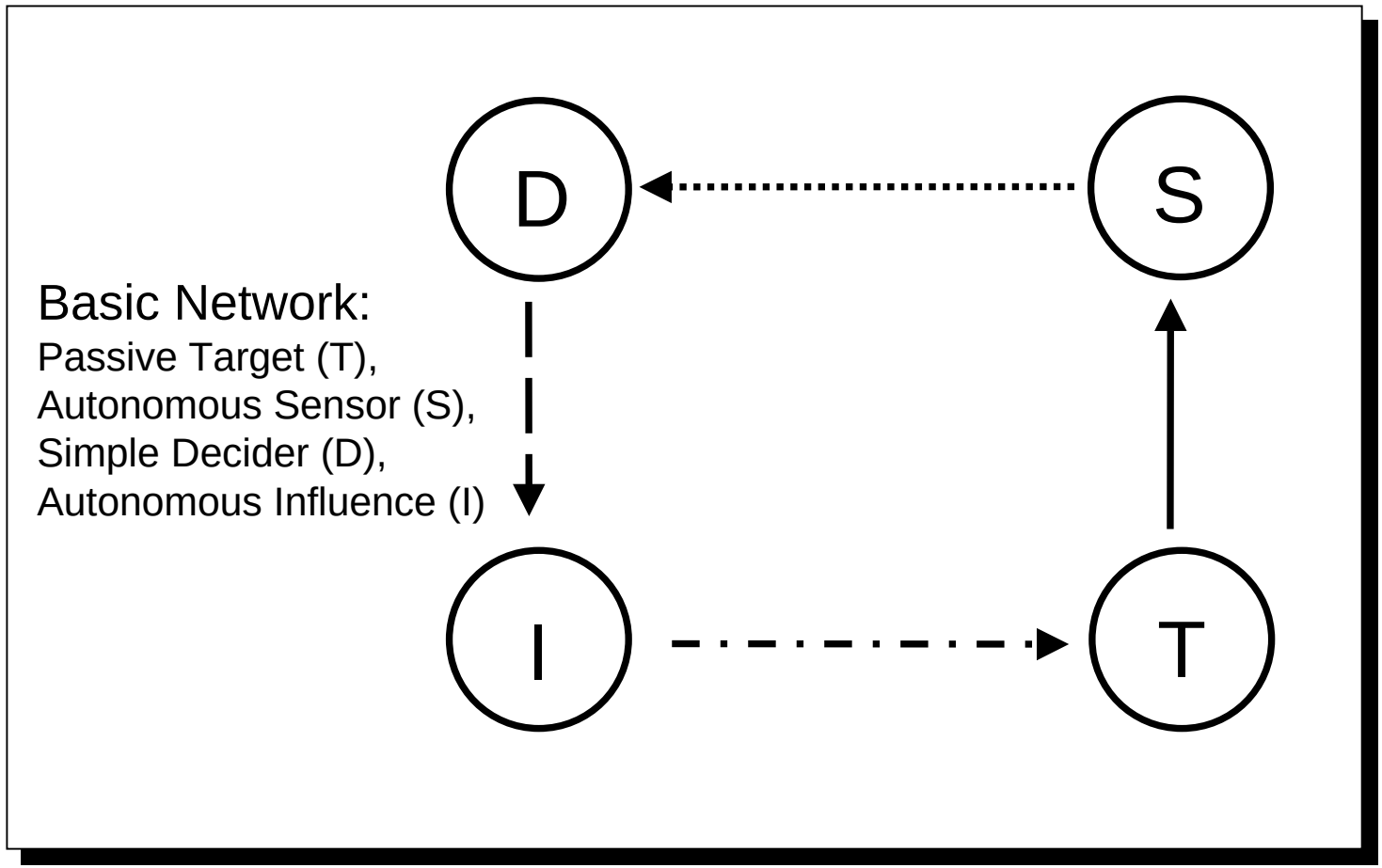
Structure

73rd MORSS

ALIDADE INCORPORATED

New Metrics and MOEs

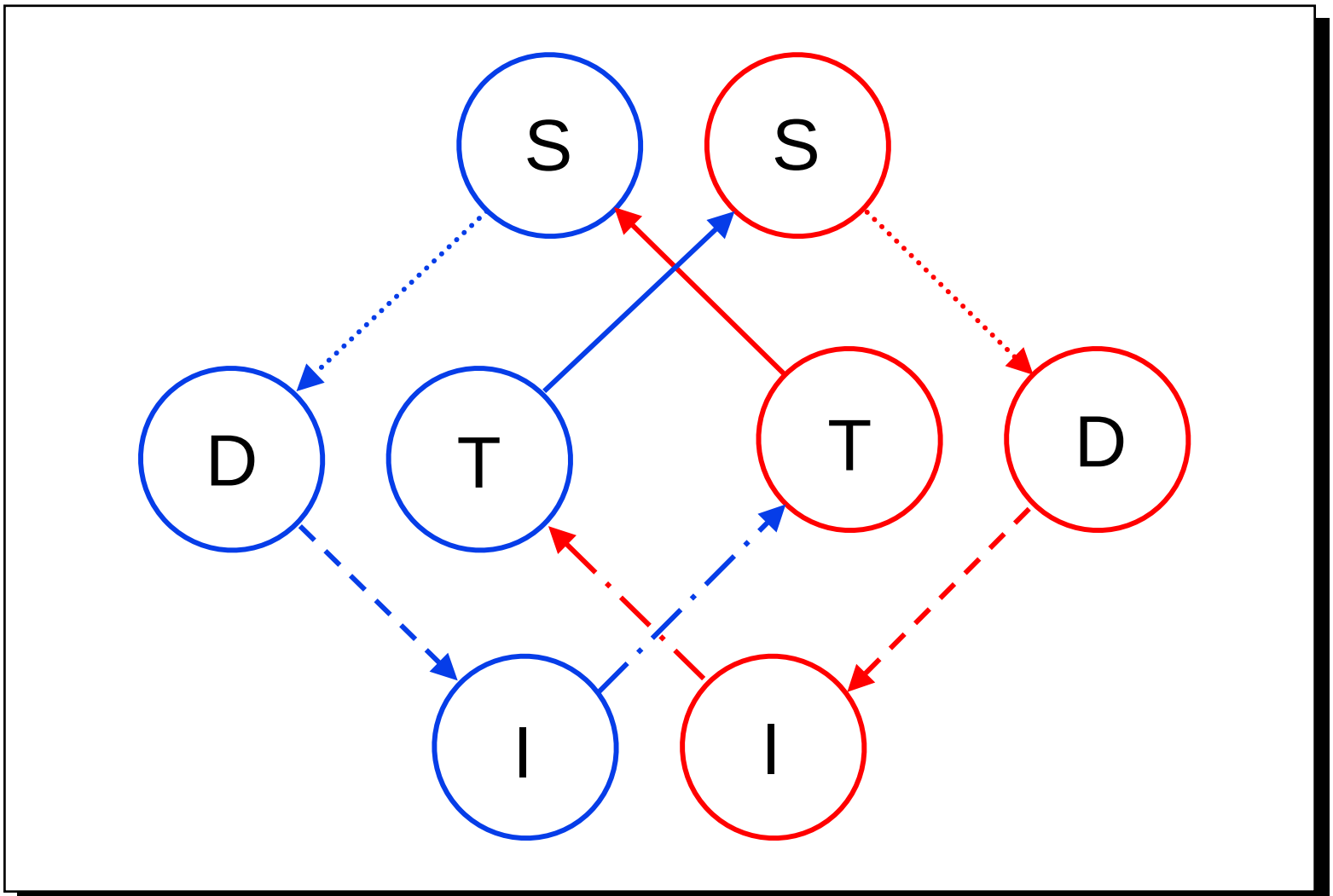
Combat Network



ALIDADE INCORPORATED

New Metrics and MOEs

Two-Sided Simple Combat

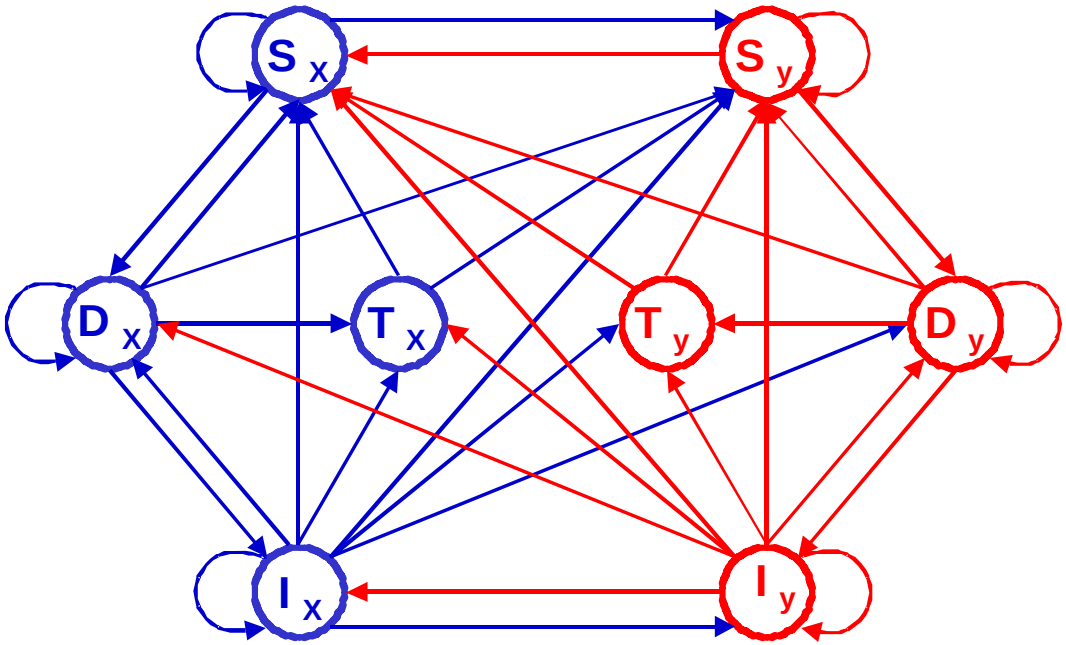


ALIDADE INCORPORATED

New Metrics and MOEs

Allowable Connections

Simplest complete combat network



S: Sensor
D: Decision Maker
I: Influencer
T: Target

ALIDADE INCORPORATED

New Metrics and MOEs

Adjacency Matrix

Adjacency Matrix for Simplest, Complete Combat Network

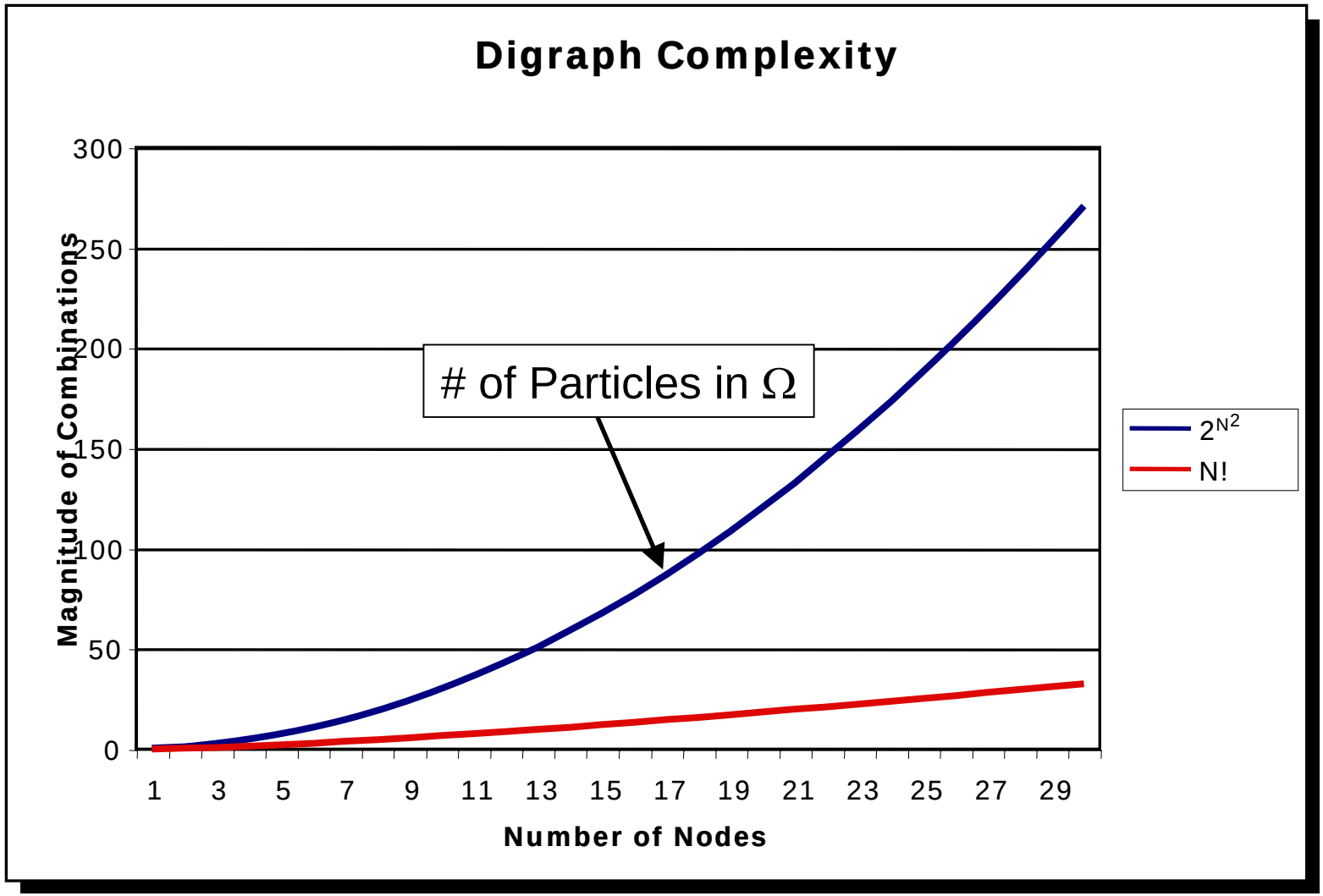
	S_x	D_x	I_x	T_x	S_y	D_y	I_y	T_y
S_x	1	1	0	0	1	0	0	0
D_x	1	1	1	1	1	0	0	0
I_x	1	1	1	1	1	1	1	1
T_x	1	0	0	0	1	0	0	0
S_y	1	0	0	0	1	1	0	0
D_y	1	0	0	0	1	1	1	1
I_y	1	1	1	1	1	1	1	1
T_y	1	0	0	0	1	0	0	0

row maps directionally to column = 1, 0 otherwise

ALIDADE INCORPORATED

New Metrics and MOEs

Combat Model Potential Complexity



ALIDADE
INCORPORATED

New Metrics
and MOEs

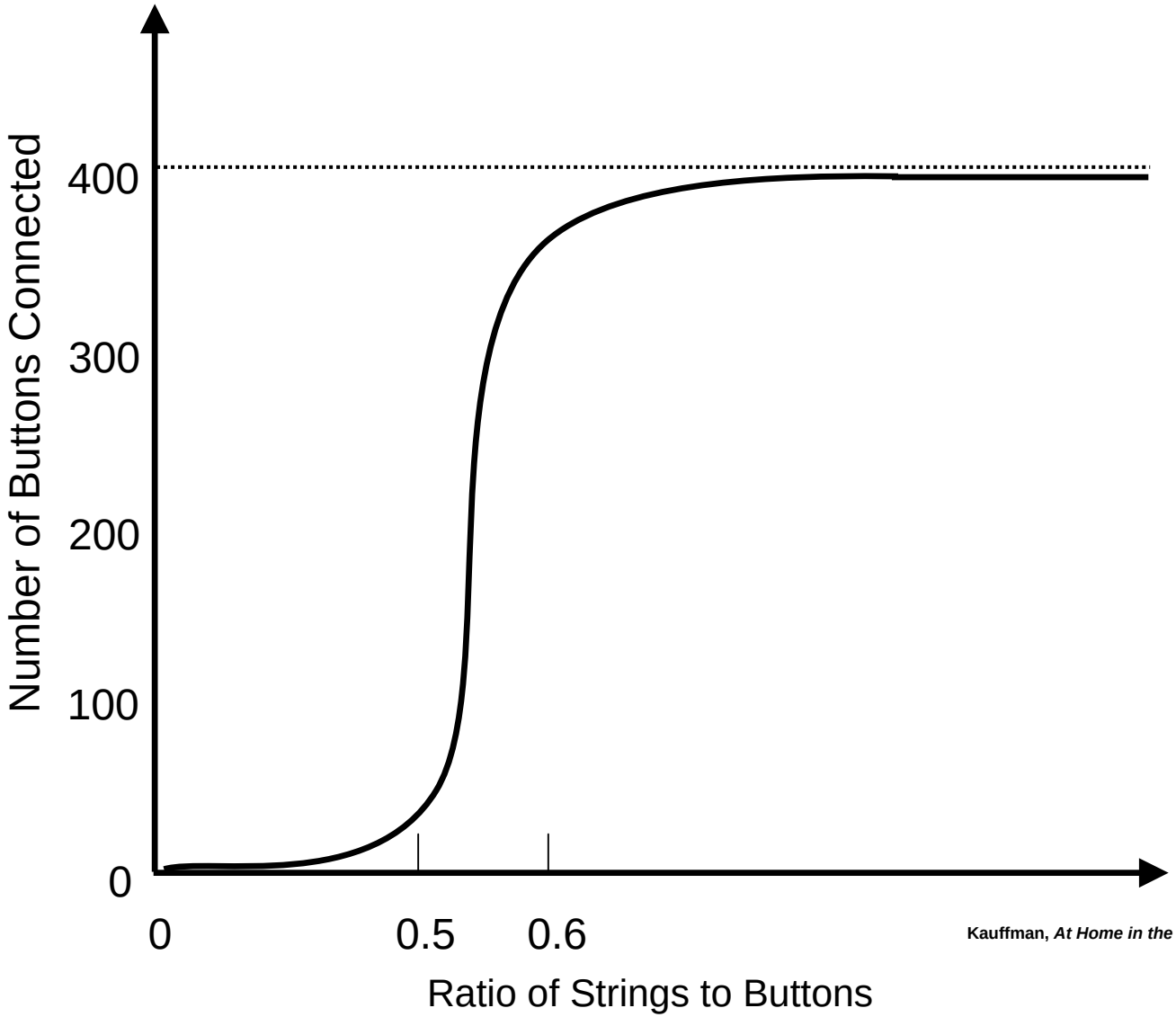
Dynamics

73rd MORSS

ALIDADE INCORPORATED

New Metrics and MOEs

Buttons and Strings

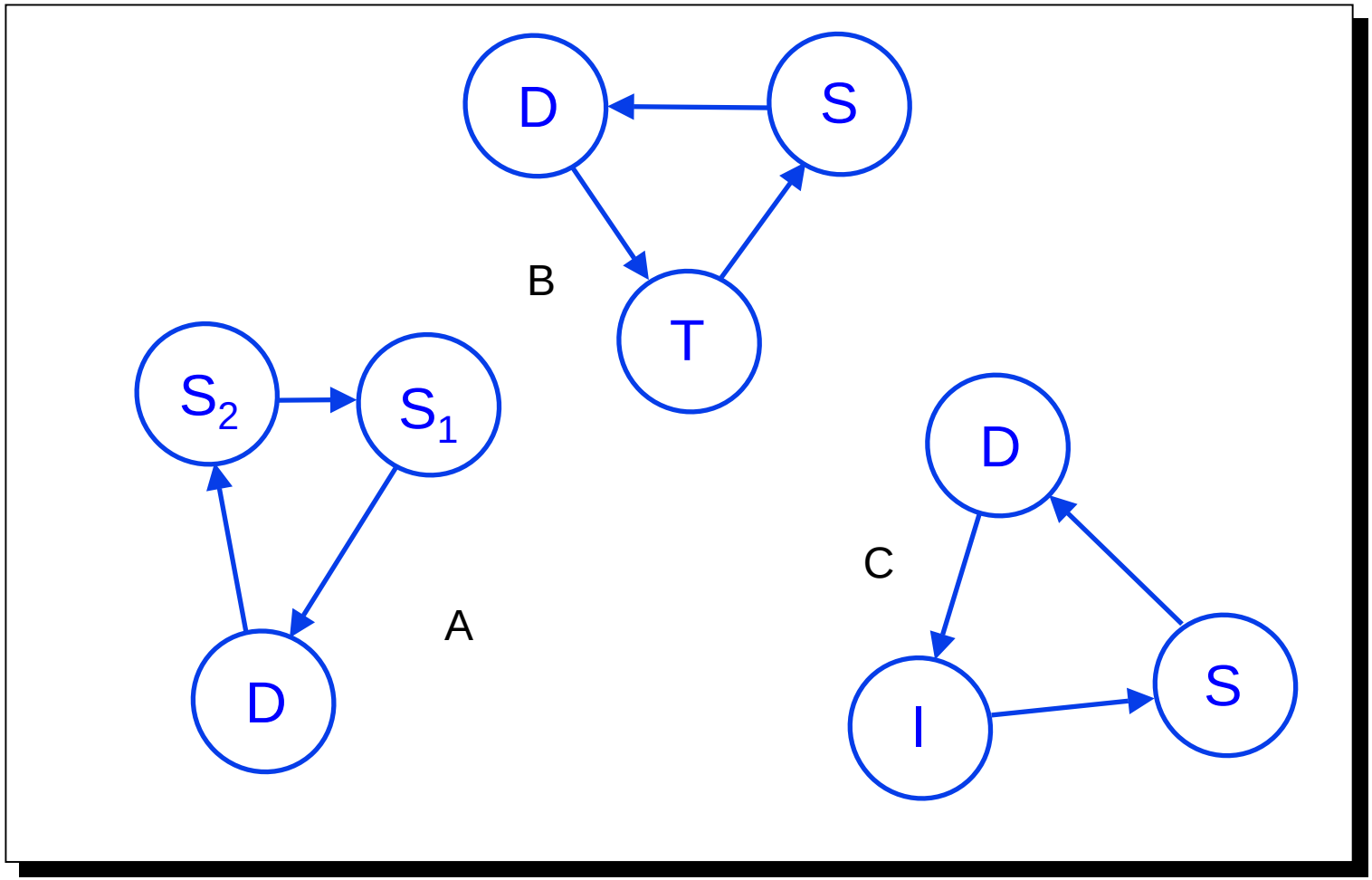


Kauffman, *At Home in the Universe,* p.57

ALIDADE INCORPORATED

New Metrics and MOEs

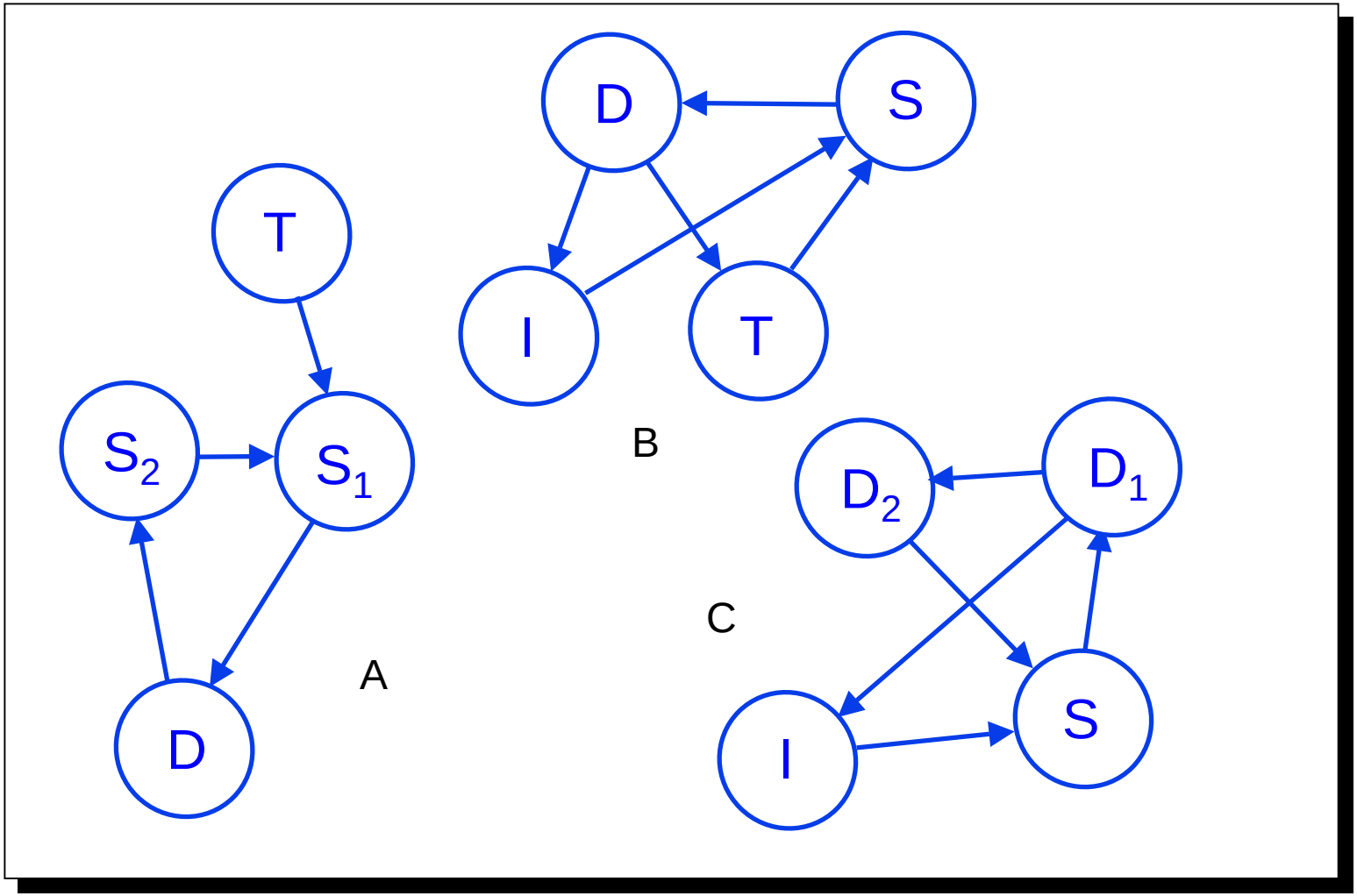
Control Cycles



ALIDADE INCORPORATED

New Metrics and MOEs

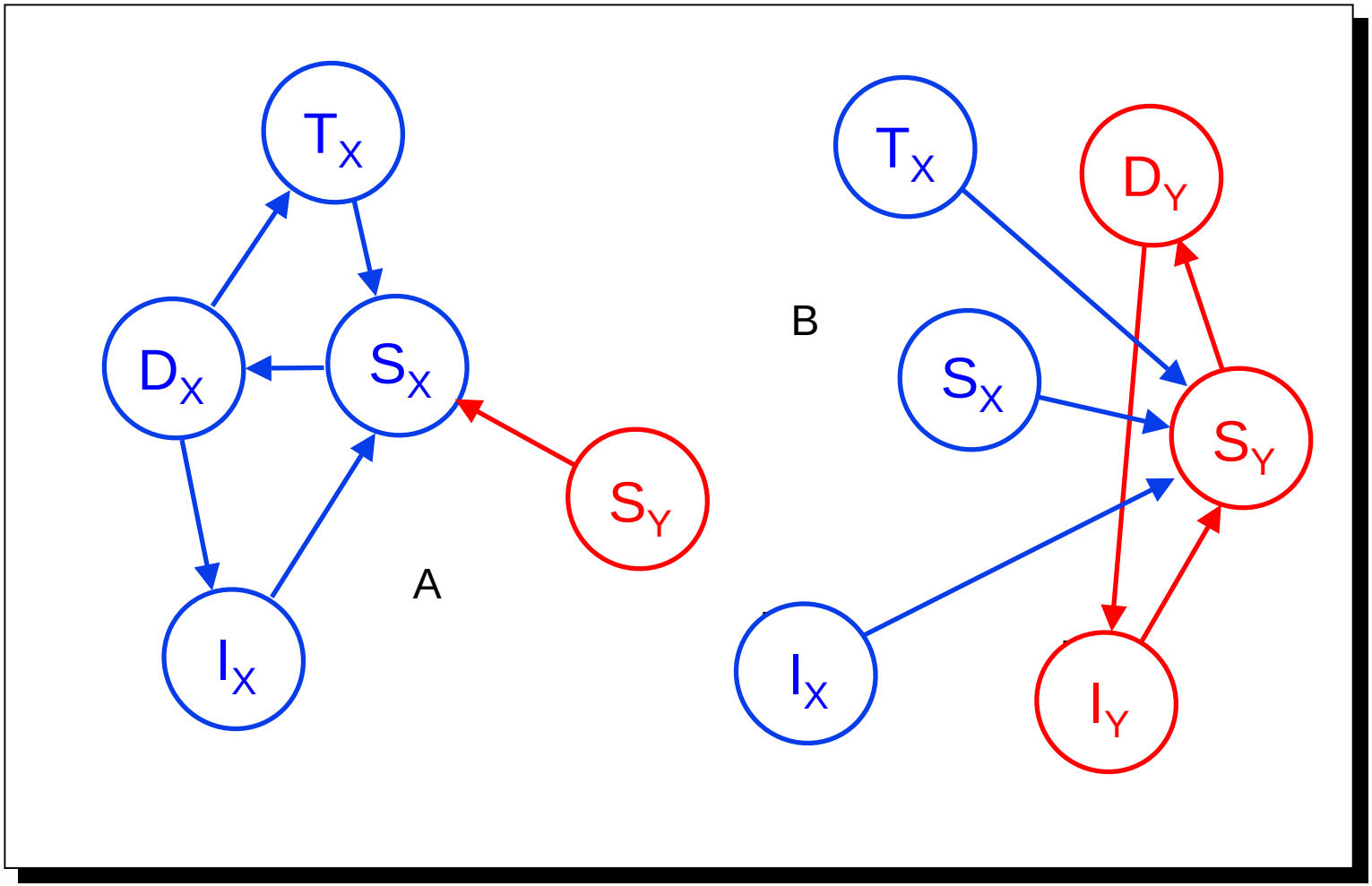
Catalytic Control Cycles



ALIDADE INCORPORATED

New Metrics and MOEs

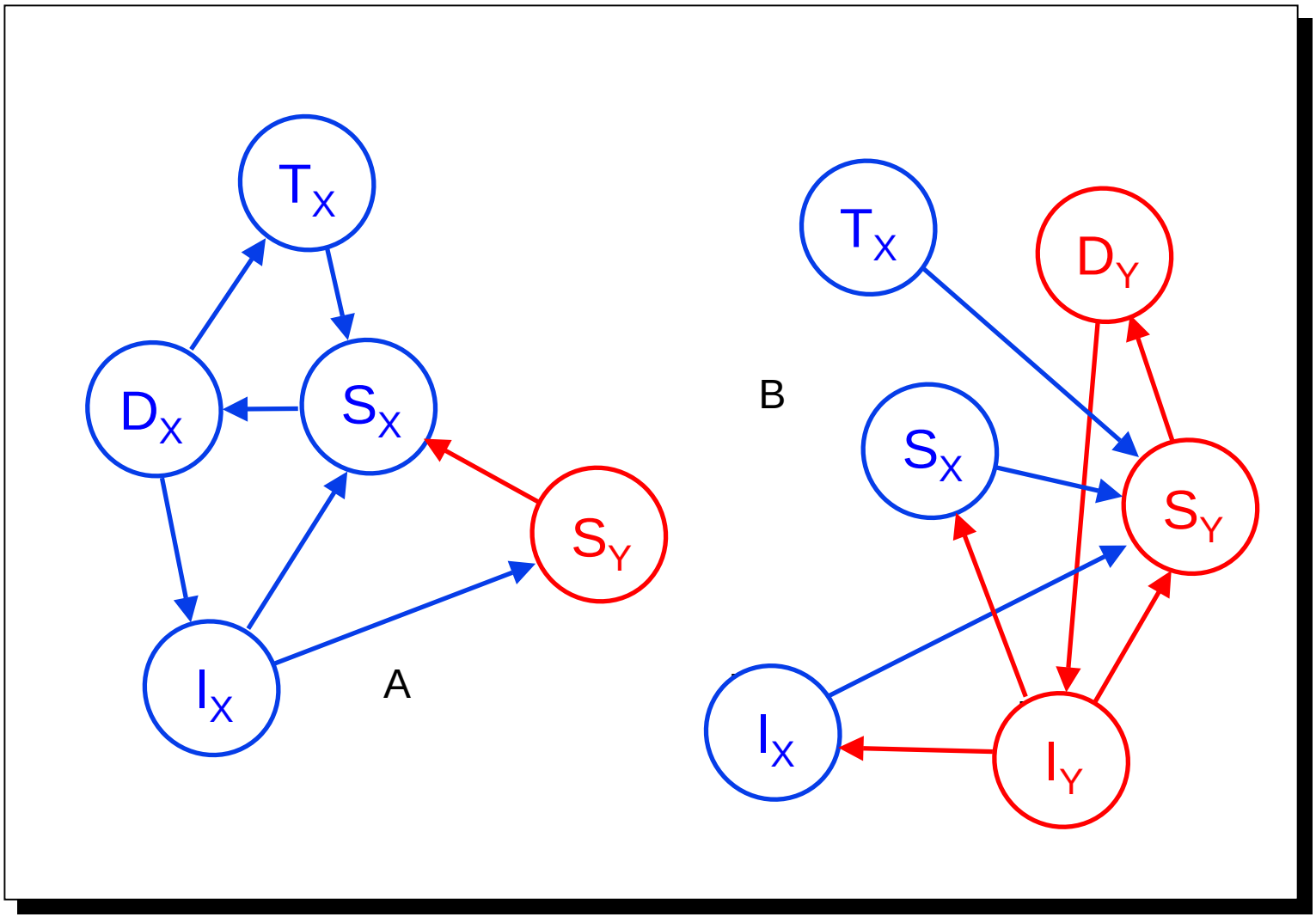
Catalytic Competitive Cycles



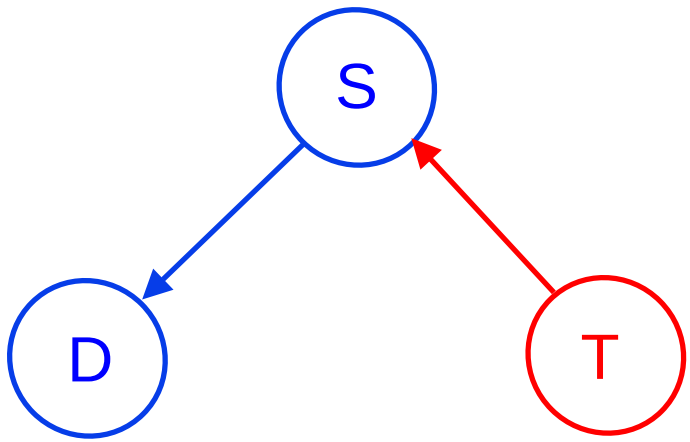
ALIDADE INCORPORATED

New Metrics and MOEs

Combat Cycles



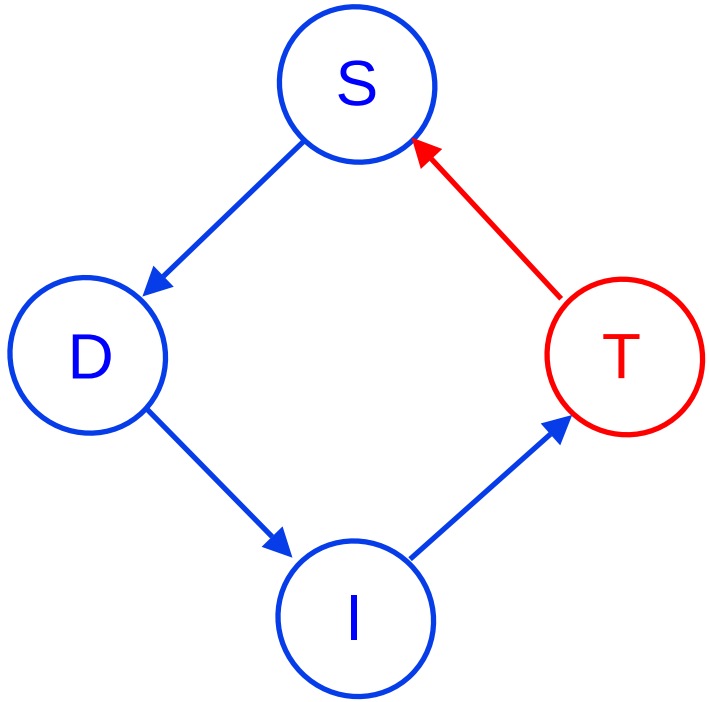
No Cycle



$$\begin{array}{c} \\ T \\ S \\ D \end{array} \begin{array}{c} \begin{array}{ccc} T & S & D \end{array} \\ \begin{pmatrix} 0 & 0 & 0 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \end{pmatrix} \end{array}$$

$$\lambda_{PFE} = 0$$

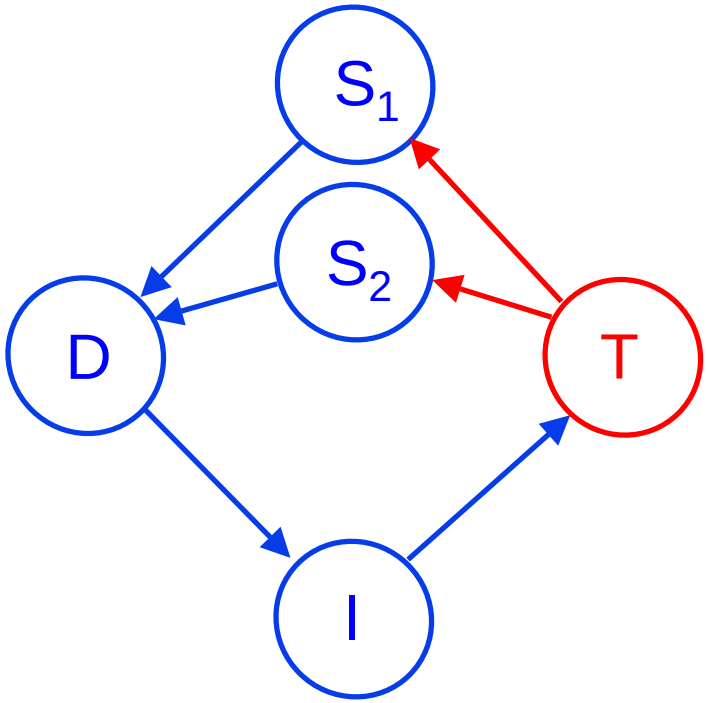
Cycle



$$\begin{array}{c} \\ T \\ S \\ D \\ I \end{array} \begin{array}{c} \begin{array}{cccc} T & S & D & I \end{array} \\ \begin{pmatrix} 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{pmatrix} \end{array}$$

$$\lambda_{PFE} = 1$$

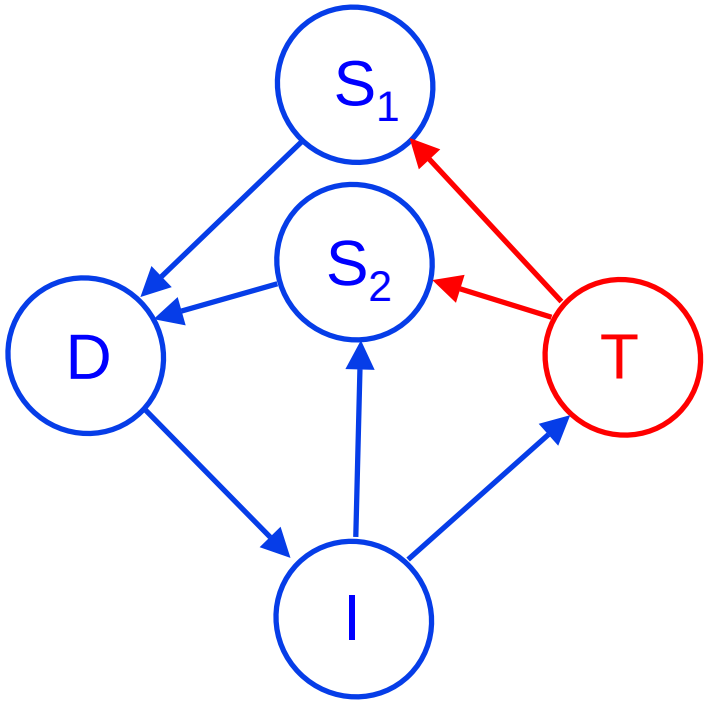
Autocatalytic Set



	T	S_1	S_2	D	I
T	0	0	0	0	1
S_1	1	0	0	0	0
S_2	1	0	0	0	0
D	0	1	1	0	0
I	0	0	0	1	0

$\lambda_{PFE} = 1.19$

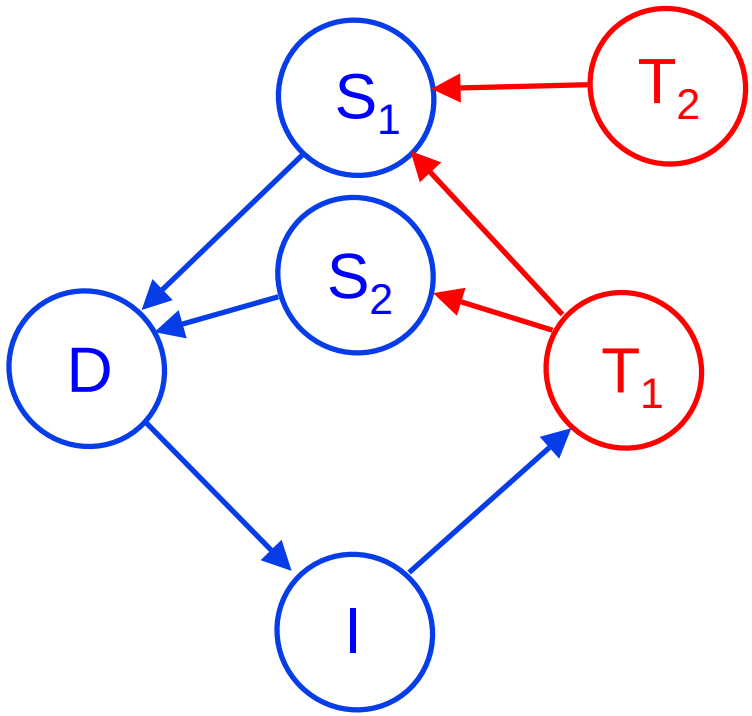
Autocatalytic Set



	T	S_1	S_2	D	I
T	0	0	0	0	1
S_1	1	0	0	0	0
S_2	1	0	0	0	1
D	0	1	1	0	0
I	0	0	0	1	0

$\lambda_{PFE} = 1.35$

Autocatalytic Set



	T_1	T_2	S_1	S_2	D	I
T_1	0	0	0	0	0	1
T_2	0	0	0	0	0	0
S_1	1	1	0	0	0	0
S_2	1	0	0	0	0	0
D	0	0	1	1	0	0
I	0	0	0	0	1	0

$\lambda_{PFE} = 1.19$

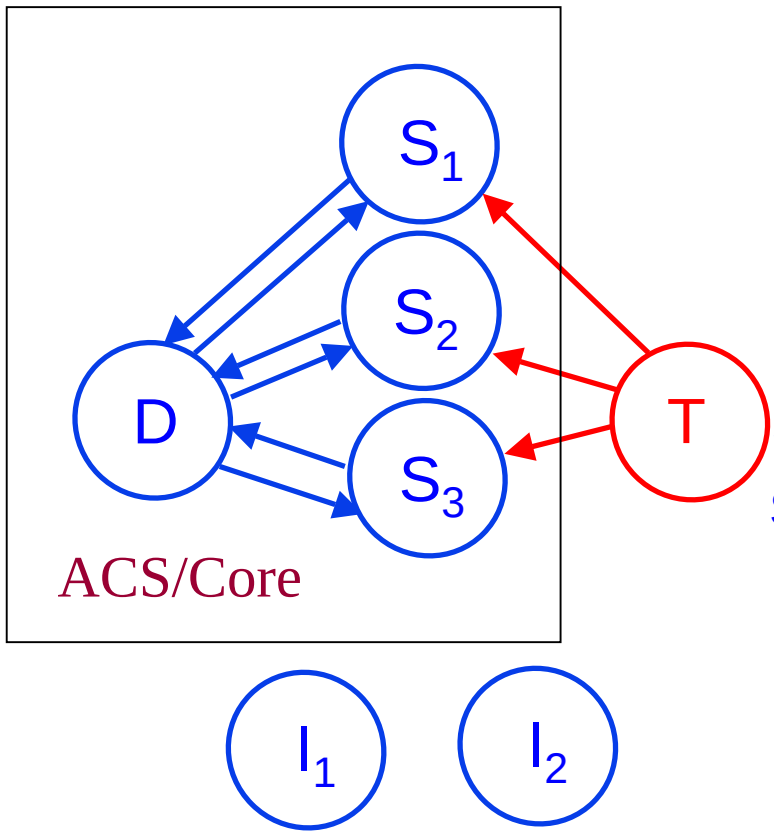
Evolution

ALIDADE INCORPORATED

New Metrics and MOEs

Core Shift

Time Step 1

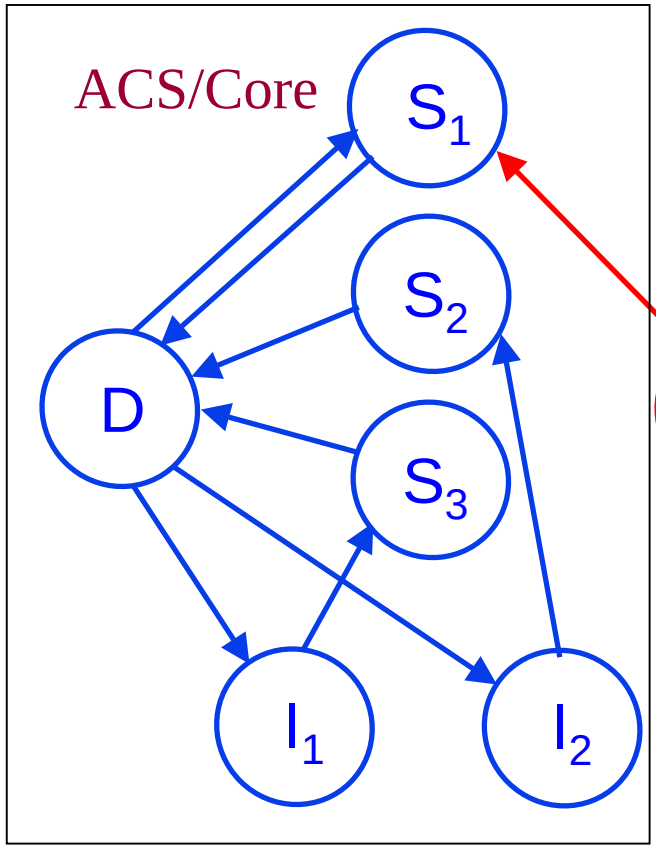


	T	S_1	S_2	S_3	D	I_1	I_2
T	0	0	0	0	0	0	0
S_1	1	0	0	0	1	0	0
S_2	1	0	0	0	1	0	0
S_3	1	0	0	0	1	0	0
D	0	1	1	1	0	0	0
I_1	0	0	0	0	0	0	0
I_2	0	0	0	0	0	0	0

$\lambda_{PFE} = 1.73$

Core Shift

Time Step 2

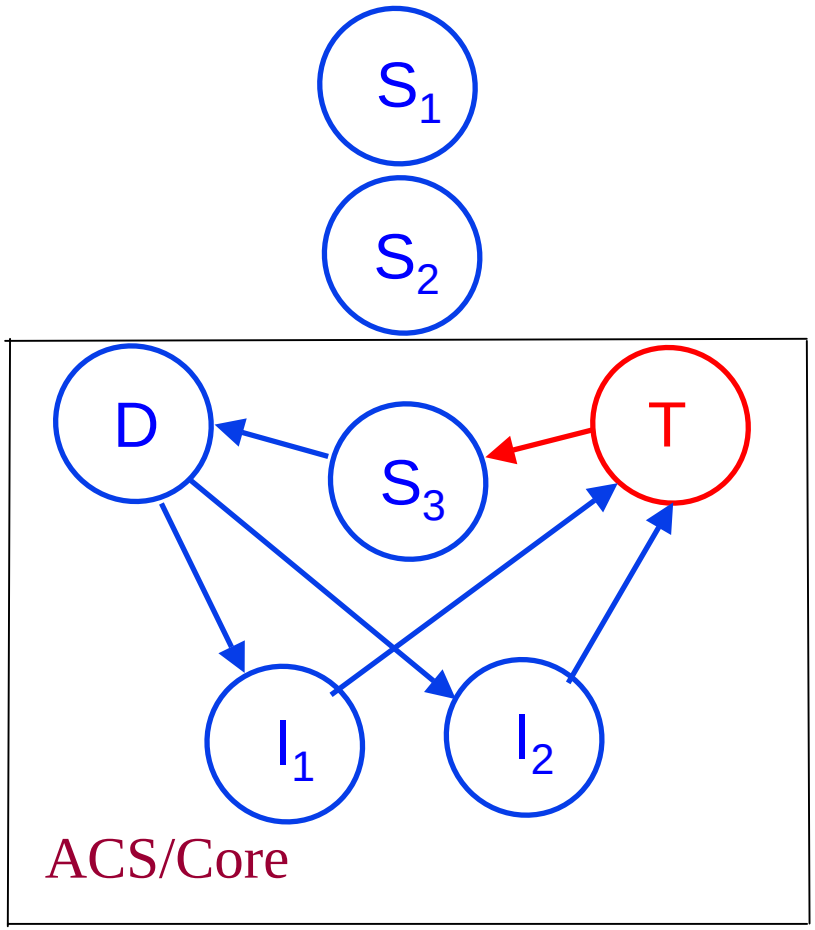


	T	S_1	S_2	S_3	D	I_1	I_2
T	0	0	0	0	0	0	0
S_1	1	0	0	0	1	0	0
S_2	0	0	0	0	0	0	1
S_3	0	0	0	0	0	1	0
D	0	1	1	1	0	0	0
I_1	0	0	0	0	1	0	0
I_2	0	0	0	0	1	0	0

$\lambda_{PFE} = 1.52$

Core Shift

Time Step 3

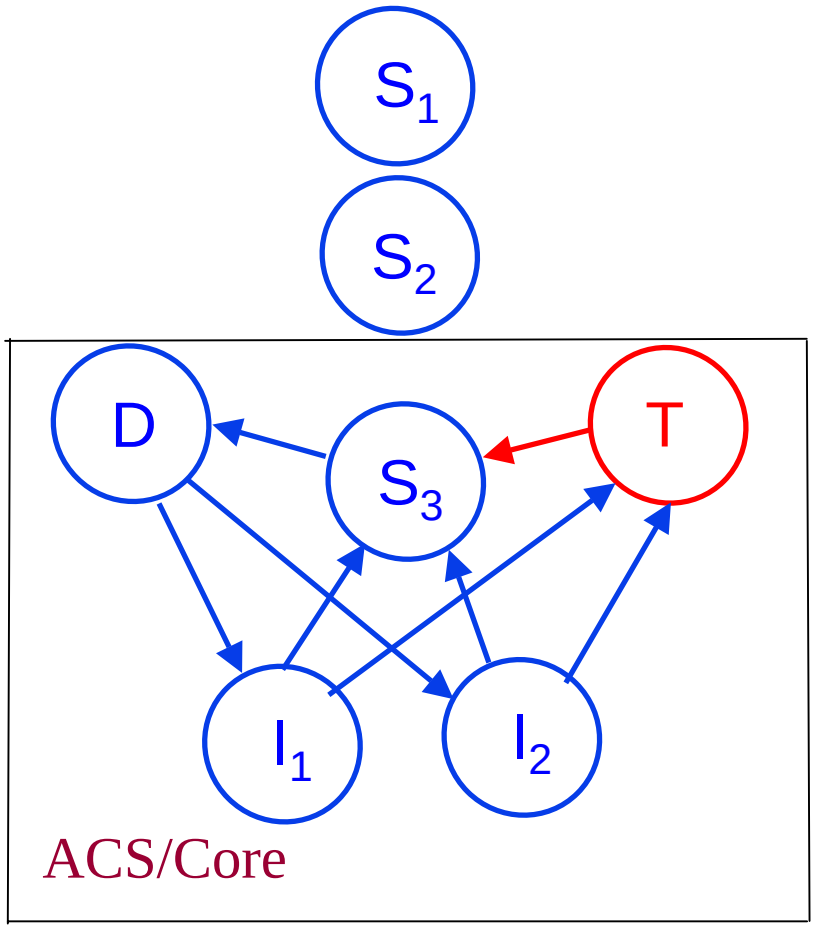


	T	S_1	S_2	S_3	D	I_1	I_2
T	0	0	0	0	0	1	1
S_1	0	0	0	0	0	0	0
S_2	0	0	0	0	0	0	0
S_3	1	0	0	0	0	0	0
D	0	0	0	1	0	0	0
I_1	0	0	0	0	1	0	0
I_2	0	0	0	0	1	0	0

$\lambda_{PFE} = 1.19$

Core Shift

Time Step 4



	T	S_1	S_2	S_3	D	I_1	I_2
T	0	0	0	0	0	1	1
S_1	0	0	0	0	0	0	0
S_2	0	0	0	0	0	0	0
S_3	1	0	0	0	0	1	1
D	0	0	0	1	0	0	0
I_1	0	0	0	0	1	0	0
I_2	0	0	0	0	1	0	0

$\lambda_{PFE} = 1.50$

ALIDADE INCORPORATED

New Metrics and MOEs

Network Metric Thumb Rules

Experimentation and Analysis

Metric	Range	Operational Significance
Number of nodes, n	n > ~100	Network effects unlikely to occur with n < 50
Number of links, l	l < ~2n	l << 2n, too brittle l >> 2n, too much overhead
Degree distribution	Skewed	Adaptivity, modularity
Largest hub	< 100 links	Hub appears, recedes by reconnection 5% of links
Average path length	log(n)	Short distances even for large networks (e.g., 10^4 nodes → Average path length = ~4)
Clustering	Skewed	Hierarchy, organization
Betweenness	Skewed	Cascade control
Path horizon	log(n)	Self-synchronization
Susceptibility/ Robustness	Low (random removal) High (focused removal)	Hubs should be kept obscure until needed, damage abatement/repair schemes
Neutrality Rating	(0, 1)	Increased network effects, decreased susceptibility, tipping points
Coefficient of Networked Effects	(0, 1)	Network effects PFE/n

ALIDADE
INCORPORATED

Complex Systems Research

Process Innovation & Analysis

Strategic Investment Advice

Future Concept Generation

Corporate/Government War Games & Events

Questions?